Superconducting Nonlinear Kinetic Inductance Devices

Completed Technology Project (2011 - 2016)

Project Introduction

Superconducting quantum interference devices, or SQUIDs, are by far the most sensitive magnetometers available, but two issues limit their commercial potential: their complicated and costly fabrication process and their unsuitability for large-scale array multiplexing. We propose developing a new kind of superconducting magnetometer, a superconducting kinetic inductance magnetometer (SKIM), that we evision will replace the SQUID due to its simple fabrication and its capability for high-density multiplexing, while matching the SQUID's exquisite sensitivity. A SQUID consists of a loop of superconducting material that is interrupted by Josephson junctions at two locations. A Josephson junction is a weak link between two superconducting regions, and can be realized by using an insulator, normal metal, or special geometry for the weak link. This makes the fabrication process relatively complicated, as multiple materials are required. The SKIM will consist of a single layer of superconducting material, so its fabrication will be very simple and much cheaper than that of SQUIDs. In addition, SQUIDs are difficult to multiplex on a large scale because each device requires ~6 connections, all of which must go into a cryostat where the device is kept. The SKIM, on the other hand, will benefit from an elegant multiplexing scheme in which all of the devices in an array can be read out simultaneously on a single line, using signal processing techniques. These advantages will prove to be important for many applications. SQUIDs currently have many applications that are of interest to NASA. They are routinely used for geomagnetic surveying, which would be applicable to NASA's planetary science missions. They are also useful for non-destructive evaluation (NDE), where they can detect hidden flaws in a material by measuring the magnetic field after the material is magnetized. This has been used for testing various airplane parts, and translates into an important safety procedure for NASA missions. They even have applications in medical imaging, where they are widely used for magnetoencephalography, a brain imaging technique. All of these cases would benefit from replacing SQUIDs with SKIMs. The SKIMs' simpler fabrication process would make them cheaper, and their high-density multiplexing capability would allow them to be used in large arrays, which could be used to measure large areas of magnetic field data at a time. This project will require a combination of analytics, simulation, fabrication, and experiment. First, analytical calculations and planar electromagnetic simulations will be employed to design the SKIM structure. Devices would be fabricated at NASA's Jet Propulsion Laboratory, so partnership with NASA will be essential for the project. Experiments would be done in a cryogenic testing setup. After demonstrating the performance of a single SKIM device, we will study arrays, with the goal of ~100 working devices. In addition to the extra fabrication and experimental considerations that must be dealt with for arrays, we will have to perform more analytics and simulations to deal with the issue of crosstalk between SKIMs.

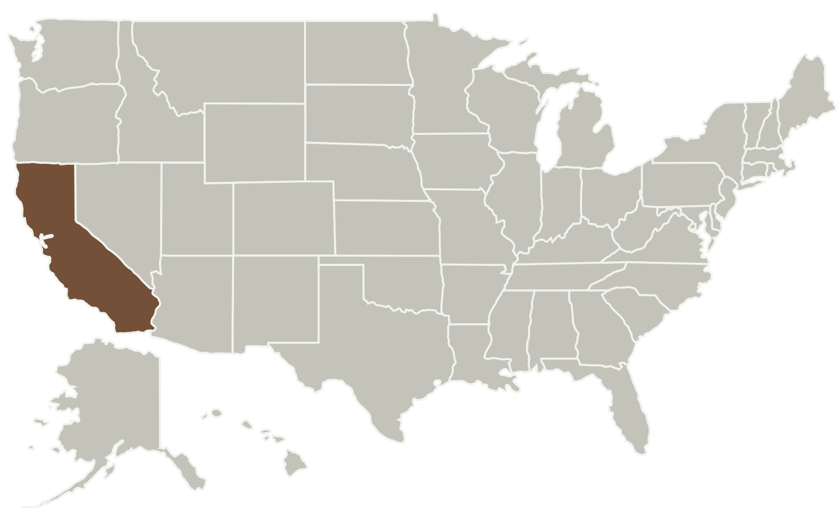
Anticipated Benefits

Project Image Superconducting Nonlinear Kinetic Inductance Devices

Table of Contents

SQUIDs currently have many applications that are of interest to NASA. They are routinely used for geomagnetic surveying, which would be applicable to NASA's planetary science missions. They are also useful for non-destructive evaulation (NDE), where they can detect hidden flaws in a material by measuring the magnetic field after the material is magnetized. This has been used for testing various airplane parts, and translates into an important safety procedure for NASA missions. They even have applications in medical imaging, where they are widely used for magnetoencephalography, a brain imaging technique. All of these cases would benefit from replacing SQUIDs with SKIMs. The SKIMs' simpler fabrication process would make them cheaper, and their high-density multiplexing capability would allow them to be used in large arrays, which could be used to measure large areas of magnetic field data at a time.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology(CalTech)	Lead Organization	Academia	Pasadena, California

Primary U.S. Work Locations
California

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

California Institute of Technology (CalTech)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Sunil Golwala

Co-Investigator:

Aditya S Kher

Images

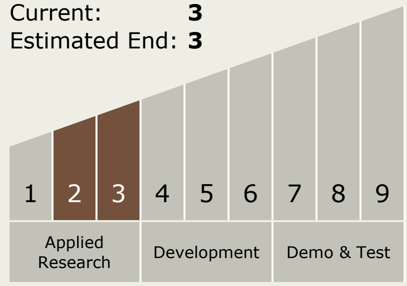
11496-1363266302866.jpg
Project Image Superconducting Nonlinear Kinetic Inductance Devices
(https://techport.nasa.gov/image/1829)

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX14 Thermal Management Systems
  └ TX14.3 Thermal Protection Components and Systems
    └ TX14.3.2 Thermal Protection Systems

Target Destinations

Earth, Mars, Others Inside the Solar System